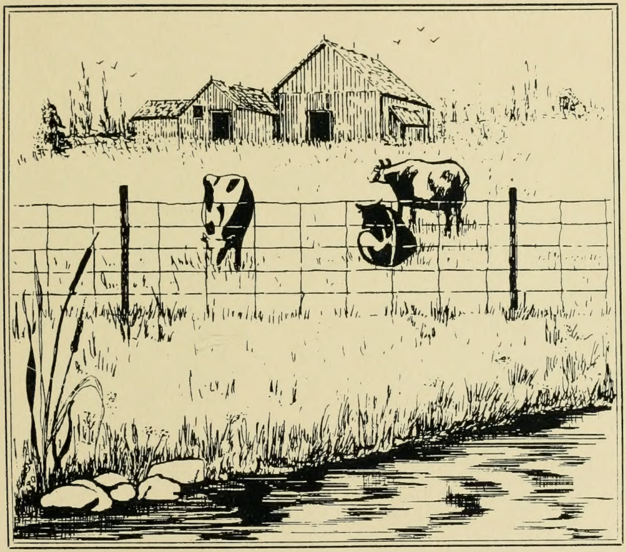
2308

CLEAN UP RURAL BEACHES (CURB) PLAN

FOR THE FANSHAWE, PITTOCK AND WILDWOOD RESERVOIRS



PRODUCED BY
THE UPPER THAMES RIVER
CONSERVATION AUTHORITY

FOR THE ONTARIO MINISTRY OF THE ENVIRONMENT

ISBN 0-7729-8650-9

DISCLAIMER

This report has been reviewed by the local Technical Steering Committee and approved for publication. Approval does not necessarily signify that the contents reflect the position and/or policies of individual agencies.

FOREWORD

This report is one of a series produced under the Provincial Rural Beaches Program. The objective of the Program is to identify the relative impact of pollution sources, and develop a course of action leading to the restoration and long term maintenance of acceptable water quality at provincial rural beaches.

Significant enrichment and bacterial contamination in southern Ontario rivers and lakes originates from rural sources. The discharge of waste material to streams can result in elevated bacterial concentrations, nuisance algae blooms, fish kills, and present a potential health hazard to humans and livestock using the water. Watershed studies have found that a multitude of pollution sources and pathways may affect beaches in Ontario. These include:

1) Urban sanitary and stormwater runoff,
2) Direct livestock manure access to watercourses,
3) Inadequate manure management practices,
4) Direct discharge of milkhouse wastes,
5) Contaminated field tile systems, and
6) Faulty septic systems

The impact upon beaches of any of these sources, either singly or in combination, can range from a few days of elevated concentrations to complete seasonal closures.

Numerous beach closings in 1983 and 1984, drew public and government attention to the severity of this water quality problem. In 1985, the Ontario Ministry of the Environment's (MOE) Water Resources Branch formulated the Provincial Rural Beaches Strategy Program. Directed by the Provincial Rural Beaches Planning and Advisory Committee, it includes representatives from MOE, Ministry of Agriculture and Food (OMAF), and Ministry of Natural Resources (MNR).

With financial and technical assistance from the MOE, local Conservation Authorities carry out studies under the direction of a local technical steering committee. Chaired by an MOE regional staff, the committees typically include representation from OMAF, MNR, the Medical Officer of Health, Conservation Authority, the local Federation of Agriculture, and a local farmer. The chairs of the local committees assure communication between all the projects by participating on the Provincial Committee.

The primary objective of each local study is to identify the relative impact of pollution sources, their pathways to beaches, and to develop a Clean Up Rural Beaches (CURB) plan specific to the watershed upstream of each beach. The CURB plan develops remedial strategy options and respective cost estimates for each beach through:

1) Field inspections,
2) Farmer consultations,
3) Water quality monitoring, and
4) Basic mathematical modelling techniques.

Recommended actions will include both measures for specific beaches and broader scale Provincial measures based on cumulative results of component studies.

The following related research projects were also MOE funded and undertaken by various Conservation Authorities to improve our understanding of bacterial and nutrient dynamics:

1) Insitu bacterial survival studies determine longevity: in watercourses, offshore of beaches, in sediments, and in milkhouse washwater tiles.

2) Biotracer studies determine the speed and nature of travel for bacteria introduced into a watercourse.

3) A liquid manure spreading study examines bacterial movement through the soil column and exiting field tile drains.

4) A target sub-basin study evaluates the effectiveness of a watershed with comprehensive remedial measures.

Numerous demonstration farms have been established with the cooperation of local farmers to display innovative management practices. Research continues on their effectiveness at improving water quality.

Comments and/or questions on this report are welcome. Please send written comments to:

Chairman
Provincial Rural Beaches Planning and Advisory Committee
c/o Environment Ontario
Water Resources Branch
135 St. Clair Ave. W.
Suite 100
Toronto, Ontario
M4V 1P5

A Clean Up Rural Beaches Plan(CURB)
for Fanshawe, Pittock and Wildwood Reservoirs in the Upper Thames River Conservation Authority Watershed

by David G. Hayman
Rural Water Quality Program Co-ordinator

Prepared for: The Ontario Ministry of the Environment

TABLE OF CONTENTS

List of Figures i
List of Tables ii
List of Appendices ii

Acknowledgements iii

Executive Summary iv

1.0 INTRODUCTION 1
- **1.1 Beach Closing History** 1
  - 1.1.1 Fanshawe Reservoir 1
  - 1.1.2 Pittock Reservoir 1
  - 1.1.3 Wildwood Reservoir 3

2.0 CLEAN UP RURAL BEACHES MODEL 3
- **2.1 Model Development** 3
- **2.2 Model Information** 3
- **2.3 Model Predictions** 4
  - 2.3.1 Fecal Coliforms 6
    - 2.3.1.1 Rural Impacts 6
    - 2.3.1.2 Urban & Industrial Impacts 10
  - 2.3.2 Total Phosphorus 10
    - 2.3.2.1 Rural Impacts 10
    - 2.3.2.2 Urban & Industrial Impacts 11
- **2.4 Field Evaluation** 11
  - 2.4.1 Fanshawe Reservoir 14
  - 2.4.2 Pittock Reservoir 16
  - 2.4.3 Wildwood Reservoir 20

3.0 CLEAN UP RURAL BEACHES PLAN 21
- **3.1 Cost/Effectiveness Analysis for Remedial Action** 23
  - 3.1.1 General Trends 29
  - 3.1.2 Fanshawe Reservoir 29
  - 3.1.3 Pittock Reservoir 30
  - 3.1.4 Wildwood Reservoir 31
- **3.2 Implementation Strategy** 32
  - 3.2.1 Manure Spills//Discharges 34
  - 3.2.2 Livestock Access 34
  - 3.2.3 Milkhouse Washwater 35
  - 3.2.4 Unacceptable Septic Systems 36
  - 3.2.5 Manure Runoff 37
  - 3.2.6 Erosion 37

4.0 REFERENCES CITED

5.0 APPENDICES

LIST OF FIGURES

Figure 1: Watershed Areas of Fanshawe, Wildwood and Pittock Reservoirs within the Upper Thames River Conservation Authority Jurisdiction.

Figure 2: Relative Spring and Summer Contributions of Fecal Coliforms to the Beaches of Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).

Figure 3: Relative Event Related Contributions of Fecal Coliforms to the Beaches of Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).

Figure 4: Relative Annual Contributions of Total Phosphorus to Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).

Figure 5: Relative Event Related Contributions of Total Phosphorus (erosion not included) to Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).

Figure 6: A Comparison of Plover Mills Fecal Coliform Data Versus CURB Model Predictions in Low Flow and Event Conditions

Figure 7: A Comparison of Plover Mills Total Phosphorus Data Versus CURB Model Predictions in Low Flow and Event Conditions.

Figure 8: Plover Mills Flow Data Versus Fanshawe Beach Closures in 1983 and 1984.

Figure 9: Plover Mills Flow Data Versus Fanshawe Beach Closures in 1985 and 1986.

Figure 10: Plover Mills Flow Data Versus Fanshawe Beach Closures in 1987.

Figure 11: A Comparison of Innerkip Fecal Coliform Data Versus CURB Model Predictions in Low Flow and Event Conditions.

Figure 12: A Comparison of Innerkip Total Phosphorus Data Versus CURB Model Predictions in Low Flow and Event Conditions.

Figure 13: Innerkip Flow Data Versus Pittock Beach Closures in 1983 and 1985.

Figure 14: Innerkip Flow Data Versus Pittock Beach Closures in 1986 and 1987.

Figure 15: Innerkip Flow Data Versus Pittock Beach Closures in 1982 and 1984.

Figure 16: Average Fecal Coliform Inputs on a Hypothetical Farm with all Identified Rural Sources.

Figure 17: Average Total Phosphorus Inputs on a Hypothetical Farm with all Identified Rural Sources.

TABLES

Table 1: Summary of Survey Information from Identified Potential High Priority Livestock Operations

Table 2: Calculated Dieoff Rates for Fecal Coliforms in Fanshawe, Pittock and Wildwood Reservoirs

Table 3: Physical Properties of Fanshawe, Pittock and Wildwood Reservoirs

Table 4: Cost/Effectiveness Analysis for Abatement of Identified Sources within the Fanshawe Reservoir Watershed

Table 5: Cost/Effectiveness Analysis for Abatement of Identified Sources within the Pittock Reservoir Watershed

Table 6: Cost/Effectiveness Analysis for Abatement of Identified Sources within the Wildwood Reservoir Watershed

Table 7: Predicted Phosphorus Loading Reductions from Adoption of Conservation Tillage

APPENDICES

Appendix 1: CURB Model

Appendix 2: Field Measured Loading Data above Fanshawe and Pittock Reservoirs

ACKNOWLEDGEMENTS

The author would like to express thanks to the Upper Thames River Rural Beaches Steering Committee for their participation in program direction and editorial review of this report. The membership consisted of:

1. Art Bos, M.O.E., Chairman
2. Murray Blackie, M.O.E.
3. Andy Graham, O.M.A.F.
4. Bob Milne, O.M.A.F.
5. Norm Bird, O.M.A.F.
6. J. Paul Fish, U.T.R.C.A.
7. Bob Bedggood, Middlesex Federation of Agriculture
8. Mike Bragg, Oxford County Board of Health
9. Jim Hill, Oxford County Planning Department
10. Theresa Eichler, Perth County Planning Department

Additional thanks to Patrick Hunter, M.N.R. Aylmer District and Jim Harmer, Township of East Zorra-Tavistock for their participation in the last year of the CURB Plan development.

Craig Merkley and Ted Briggs were invaluable in their field activities, as well as their contributions to the development of the CURB Plan report.

Funding was provided by the Ministry of Environment through the Provincial Rural Beaches Strategy Steering Committee. Many thanks to the members of that committee for their technical input and financial support.

Credit also goes to Alma Fischer for her conversion of the authors handwriting into a legible manuscript. Much appreciation to Carol Shaw for her efforts in the design and typesetting of the report.

Executive Summary

A Clean Up Rural Beaches (CURB) plan was developed to identify the relative impact of pollution sources on reservoir beach closures. This report outlines an implementation strategy directed towards minimizing future restrictions on reservoir use. Additional environmental benefits associated with water quality improvement must be considered in any formulation of a financial assistance program.

Generally, the CURB model predictions were consistent with the field measured data. Variability was attributed to sedimentation and resuspension, model assumptions, undetected tile drainage contamination and/or field measured loading estimates.

Livestock access to streams and drains was found to be the most cost-effective remedial measure for control of bacterial contamination. Existing policy on access control should be reviewed.

1. A joint OMAF/MOE grant program should provide financial incentives for restricted access items.
2. The grant should not fund access projects other than complete restriction.
3. The grant program should consider financial compensation for pasture land taken out of production.
4. CA and OMAF extension staff should provide technical assistance to develop satisfactory plans which permits flexibility for unique situations.
5. OMAF initiated research is needed to determine landowner benefits to herd health and production to assist in promotion of the practice.

Milkhouse wastewater treatment appears to be the most cost-effective measure for phosphorus control. The work is particularly effective for low flow concentrations.

1. Washwater treatment trench systems should only be installed by certified contractors.
2. OMAF initiated research is needed to develop reliable, economical methods for treatment (grassed filter strips, artificially constructed wetlands, aeration of discharge, bacterial disinfection, etc.).
3. Research should also consider methods to reduce water requirements for the washing process.
4. The Dairy Inspection Branch of OMAF should require treatment or handling facilities for Class A milk sales once several options are available.
5. MOE should limit phosphorus in milkhouse wash chemicals.

Rural resident septic system improvement was the second most cost-effective measure for both bacteria and phosphorus reduction.

1. The County Health Units should develop a program to ensure septic system compliance. Extra staff and assistance from MOE and CA staff may be required.
2. All grey water should be directed to treatment systems.
3. Inspected septic systems should become registered with the real estate survey within the next five years.
4. A tax incentive program similar to the Canada Home Insulation Program (CHIP) would help the registration process. Additional staff would be needed to coordinate and implement the program through the County Health units.
5. Sewage haulers should provide a maintenance record for each pumped tank to either the health unit, the landowner or both.
6. Through joint discussions with MOE, County Health Units and township or municipal councils all small rural communities should develop and implement a domestic sewage management strategy within the next five years.

Soil erosion is the highest single contributor of phosphorus to each of the Upper Thames River C.A. reservoir beaches. The most cost-effective loading reduction approach is to target efforts to high priority areas.

1. OMAF and CA extension staff should continue promotion of soil conservation. CA staff can place more emphasis on correction in areas with a high sediment delivery to stream.

Manure storages were found to be the least cost-effective system for water quality improvements at a beach. However, severe localized water quality problems and exceedence of M.O.E. effluent standards requires manure runoff containment.

1. Grants should be revised to reflect an economic analysis of the costs not expected to be recouped by a farmer within ten years.
2. OMAF and CA extension staff should promote soil and manure testing to minimize fertilizer use to offset construction and operating costs.
3. MOE should provide environmental guidelines and construction inspection to ensure standards are met and surface or groundwater contamination is prevented.
4. More OMAF/MOE initiated research is needed to determine the most environmentally beneficial timing and application rates of manure which maximize crop benefit.
5. A provincial agricultural waste manangement policy is needed or the Agriculture Code of Practice should be revised to reflect environmental concerns.

Manure spills/discharges can be the most significant pollution source on a farm. If the occurence is in low flow conditions, downstream reservoir impacts can be serious and long-term.

1. MOE and CA staff must encourage farmers to develop a contingency plan to prevent, contain and clean up a spill/discharge. These plans should be required prior to approval for manure storage construction.
2. Animal units should be limited to cropped land base. MOE and township councils should review existing situations and develop strategies to prevent overspreading of manure.
3. MOE should license custom spreaders to be accountable for environmental impact.
4. MOE should provide more public profile on the status of investigations to encourage immediate report ing of spills/discharge.
5. Existing legislation provides for prosecution of intentional dumping or unattended spills/discharges.
6. Costs of stream rehabilitation should be borne by the spill/discharge offender.

Milkhouse washwater discharges, livestock access and unacceptable septic systems are the major sources of concern for all three reservoirs.

In the Fanshawe Reservoir watershed, initial capital costs for the required CURB strategy (assuming 100% cooperation) would be between 2.5 and 4.5 million dollars. Septic system upgrades account for 2.0 million of the total. A 1.2 to 1.6 million dollar capital outlay is needed for Pittock Reservoir with one million of this for septic system improvements. To remedy required upstream sources in the Wildwood Reservoir watershed, $120,000 to $170,000 is needed.

Due to downstream recreational benefits, at least a portion of the costs should be borne by society through provincial grants or incentives funded through OMAF and MOE. To achieve any success a proactive promotional approach must be adopted. Conservation authorities provide an ideal vehicle for such a program delivery since it can cater provincial programs to local area needs. Given the watershed size, livestock farming intensity and number of identified high priority sites, two staff would be needed at the Upper Thames River Conservation Authority to facilitate implementation, targetting and monitoring of water quality changes. These personnel could be funded through a cost share agreement between MOE, OMAF and the Authority. The UTRCA Rural Beaches Steering Committee should continue to function in its advisory capacity and to maintain its liason with local agencies, government and farmer groups.

1.0 INTRODUCTION

As far back as the late seventies, reservoirs within the Upper Thames River Conservation Authority (UTRCA) have experienced beach closures due to poor water quality. Pittock Reservoir, near Woodstock, has had the most significant problems, primarily from elevated bacteria and the related public health concerns.

Based on a rash of beach closures throughout the province in 1983 and 1984, the Ontario Ministry of the Environment (OMOE) announced a Provincial Rural Beaches Strategy Program. The primary objective of the first three years of the program was to compile survey data, field studies results and literature reviews into a model to assess the impact of pollution sources at the beach.

The UTRCA has been involved in the Provincial Rural Beaches Strategy Program since its announcement. This report outlines the Clean Up Rural Beaches (CURB) plan developed in an effort to eliminate the recurring beach closures currently experienced at the Authority reservoirs; Fanshawe, Pittock and Wildwood (Figure 1).

1.1 Beach Closing History

1.1.1 Fanshawe Reservoir

By the early 1980's, Fanshawe Reservoir (Figure 1) began to follow the beach closure fate of Pittock with postings every swimming season. Blue-green algae blooms occur regularily in Fanshawe Reservoir, having closed the beach area for each of the years 1984 to 1987.

Elevated bacteria levels generally follow the bloom, however, the persistence of the algae is what keeps the reservoir posted for extended periods of time. In years without the blue-green algae blooms, high indicator bacteria counts have resulted in beach closures.

In 1988, the Ministry of the Environment installed an experimental ultra-violet light beach curtain system in an effort to deflect algae blooms and maintain lower bacteria levels within the swimming curtain area. However, an algae bloom occurred in the reservoir in mid-July. Fecal coliforms levels outside the swimming area remained within the swimming guidelines until mid-August.

1.1.2 Pittock Reservoir

Since the late 1970's, Pittock Reservoir (Figure 1), near Woodstock, Ontario, has had its recreational beaches closed for variable durations each summer. Elevated indicator bacteria levels have been the primary public health concern, accounting for closures in six of the last seven years. Blue-green algae blooms which cause aesthetic problems and potential health risks if consumed, have resulted in closures for two of the years. Records prior to 1982 only indicate closures, not dates or reasons for posting of the beach.

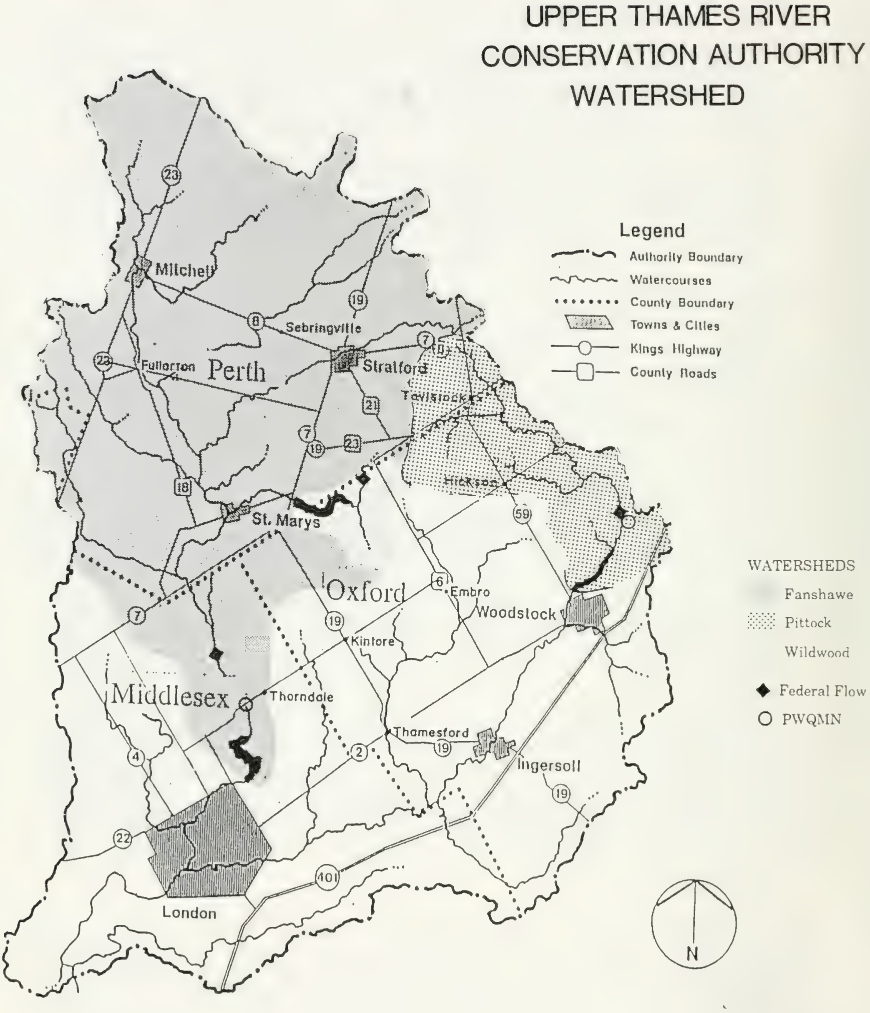


Figure 1: Watershed Areas of Fanshawe, Wildwood and Pittock Reservoirs within the Upper Thames River Conservation Authority Jurisdiction.

In years of blue-green algae blooms, elevated bacteria levels are noticed several days after the bloom first appears on the reservoir.

1.1.3 Wildwood Reservoir

High fecal coliform counts in Wildwood Reservoir (Figure 1) were recorded in 1984, which resulted in the first documented beach closure for the reservoir. The posting lasted two weeks. In 1987 and again in 1988, green algae blooms caused beach closings, mainly for aesthetic reasons, although when the blooms drifted to the beach, lack of water clarity became a swimming hazard. In 1988, elevated fecal coliform levels were above the safe swimming guideline (100/100 ml) from August 22 to the end of the summer.

2.0 CLEAN UP RURAL BEACHES MODEL

2.1 Model Development

In order to produce a Clean Up Rural Beaches (CURB) plan, all potential pollution sources contributing to beach closures had to be quantified. A workshop of the Ministry of the Environment representatives, and participating rural beaches strategy staff was organized to discuss various model approaches.

Generally, the CURB model has been adapted from the Pollution from Livestock Operations Predictor (PLOP) produced under contract to the Ministry of the Environment (Ecologistics 1988). Changes to PLOP were necessary since PLOP is a site specific pollution predictor requiring more detailed information than was available in the respective rural beaches program areas. Other sources, not addressed through PLOP, were added to the CURB model for a more complete assessment of impacts at the beach.

Following a review by the UTRCA Rural Beaches Strategy Steering Committee, some modifications were made to the preliminary model. Further scrutiny, literature review and discussions with various agencies and rural beaches staff resulted in the CURB model used for this report. Any changes to the preliminary model and reasons for these changes are documented in Appendix 1. Since all three reservoirs have experienced closures due to elevated bacterial levels and algae blooms, it was necessary to model for bacteria and phosphorus in each reservoir.

2.2 Model Information

Preliminary source identification was achieved from a visual assessment of all farms within Fanshawe, Wildwood and Pittock Reservoir watersheds (Hayman and

Merkley 1986). Potential high priority ranks were attached to any livestock operation with visual evidence of:

1. Surface runoff to open water from manure storage or feedlot areas.
2. livestock access.
3. dairy operations (for potential milkhouse washwater discharges).

An attempt was made to identify all other livestock operations by type to quantify manure production and spreading. Although tile drainage can be contaminated by drainage from silos, barns, manure storages and feedlots, the magnitude of the source was difficult to quantify. As a result, the CURB model did not consider these inputs.

The survey information was summarized and transferred to computer. Assessment rolls at township offices provided current names and addresses for each farm operation. By spring 1987, all identified potential high priority livestock operators were sent an information package which included a letter of introduction, a discussion on pollution potential from livestock operations and pamphlets on the available technical and financial assistance.

In the second year of the program, all potential high priority operators were visited to collect survey information in an attempt to quantify pollution sources (Hayman and Briggs 1987). The farm visits also served to eliminate farms from the high priority list if:

1. treatment was in place,
2. no longer a livestock operation, or
3. farm operation misidentified as dairy.

The revised file of survey information was stored in a computer database file and used to summarize the existing conditions in each reservoir watershed (Table 1).

2.3 Model Predictions

Due to the various assumptions used in the CURB model, the information cannot be considered suitable for site specific evaluations. Instead, the model was developed to collectively determine the relative impact of each source at the downstream beach. To calculate on a relative scale, the survey information was averaged to depict a typical situation for that particular reservoir watershed (Table 1). These average values were multiplied by the number of identified sources to provide annual input estimates of total phosphorus and fecal coliforms to the reservoir drainage system (Appendix 2). These model estimates do not include tile contamination by manure and/or feedlot runoff.

Table 1: Summary of Survey Information from Identified Potential High Priority Livestock Operations

	Fanshawe	Pittock	Wildwood
Area (km^2)	1310	242	141
Livestock Operations (#)	1332	308	162
Density (#/km^2)	1.02	1.27	1.15
Livestock Access			
Access Sites (#)	107	42	5
Density (#/km^2)	0.08	0.17	0.04
Avg. Hours	23	23	24
Avg. Months	6	6	6
Avg. Length (m)	465	570	305
Avg. Animal Units	37	43	17
Milkhouse Washwater			
Discharge Sources (#)	204	101	7
Density (#/km^2)	0.16	0.60	0.10
Avg. Discharge (l/day)	436	509	191
Feedlot/Manure			
Runoff Sources (#)	142	67	6
Density (#/km^2)	0.11	0.28	0.04
Storage Area (ft^2)	4161	5758	3345
Survey			
High Priority Farms (#)	545	247	24
% Surveyed	83	93	67

2.3.1 Fecal Coliforms

Transport and survival of bacteria from input point to the beach must be considered to allow for microbial dynamics.

In the water column, bacterial survival studies by the UTRCA (Hayman and Briggs 1987), and other rural beaches programs provided dieoff rate estimates (pers comm Mike Young MOE, Toronto). Under the assumption all sources are evenly distributed throughout the watershed, time of travel for bacteria from the watershed midpoint to the beach was estimated for high and low flow conditions (pers comm R. Goldt, UTRCA). Bacterial sources were subdivided into two categories to represent pulse discharges (event induced) in high flow conditions and continuous discharges (daily) in low flows. Table 2 outlines the calculated bacteria dieoff rates for both flow conditions in each reservoir.

Bacteria which survive water column transport also settle to the sediments. Studies of bacterial persistence in the sediments suggest virtually complete dieoff in the winter months. Between April and September survival was excellent (Hayman and Briggs 1987). As a result, bacterial inputs from October to March were subtracted from the annual contribution estimates. No dieoff rate was factored into the model for bacteria in the sediments the remainder of the year. This assumption is not entirely accurate since resuspension and water column dieoff is ongoing through the swimming season. However, the model does not attempt to quantify bacteria at the beach, but merely uses relative source impact. Any dieoff rate factor in the sediments would affect all bacteria in the same manner, thereby not affecting these relative comparisons.

All sources were also compared under a theoretical average event situation where all inputs occur simultaneously. The calculation was determined by dividing the total annual inputs by the estimated number of input days. Runoff events were considered to occur in twenty days out of the year, five in late fall and winter. The high flow decay factor was used for all sources including the continuous discharges.

2.3.1.1 Rural Impacts

Nearly 50% of the bacteria in Fanshawe Reservoir originates from rural sources. Of these, unacceptable septic systems (27%), usually direct grey water discharges and livestock access (19%) are the two most significant contributors (Figure 2).

In Pittock and Wildwood Reservoirs, with less urbanization, rural sources respectively account for 80% and 90% of the bacterial inputs at the beach. Again, unacceptable septic systems and livestock access are the most significant contributors (Figure 2).

For an average event situation, manure spills/discharges can become a significant contamination source. Under runoff conditions, the relative impact of rural sources on the beach at Fanshawe Reservoir is approximately 50%(Figure 3).

Table 2: Calculated Dieoff Rates for Fecal Coliforms in Fanshawe, Pittock and Wildwood Reservoirs

	Dieoff	Travel Time		Dieoff	
	Rates[1] (log/day)	High Flow[2] (hours)	Low Flow[3] (hours)	High Flow[2] (log/day)	Low Flow[3] (log/day)
Reservoir					
Fanshawe					
River	0.22	12	36	0.11	0.33
Lake	0.5	6	24	0.125	0.5
			Total	0.235	0.83
Pittock					
River	0.22	6	24	0.055	0.22
Lake	0.5	6	24	0.125	0.5
			Total	0.185	0.72
Wildwood					
River	0.22	4	16	0.037	0.147
Lake	0.5	12	48	0.25	1
			Total	0.287	1.147

[1] pers comm, M. Young, MOE Toronto 1988

[2] pulse input conditions

[3] continuous (daily) input conditions

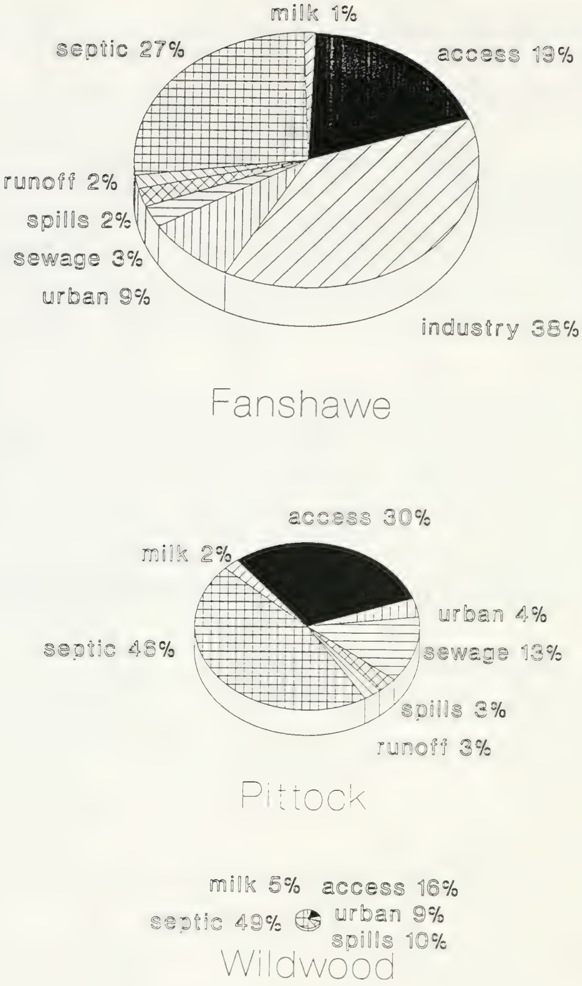


Figure 2: Relative Spring and Summer Contributions of Fecal Coliforms to the Beaches of Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).

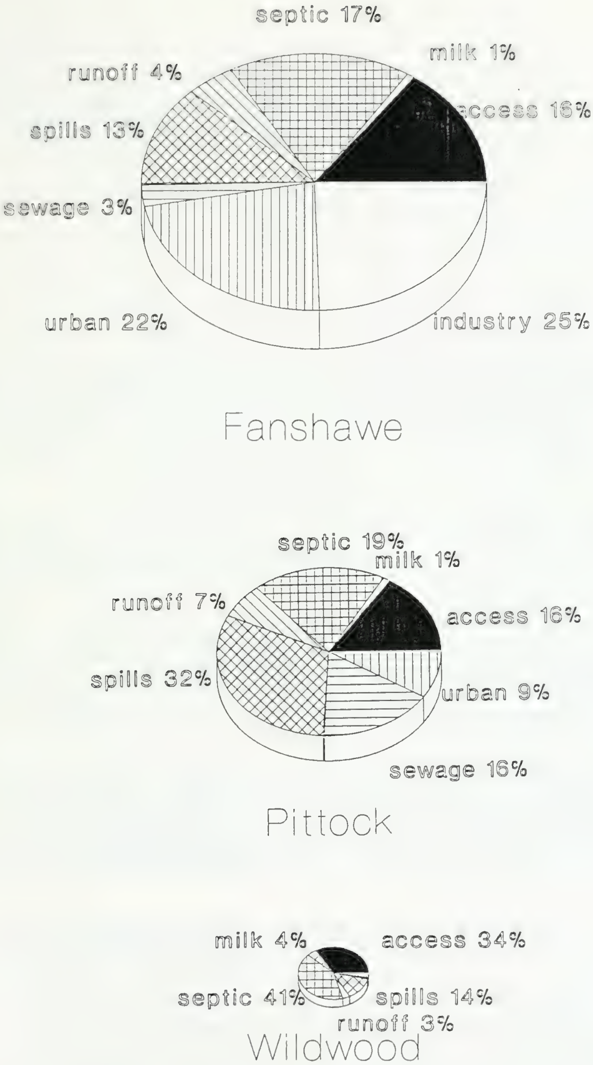


Figure 3: Relative Event Related Contributions of Fecal Coliforms to the Beaches of Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).

In April, while the Tavistock lagoon is discharging, the rural contribution of bacteria to Pittock Reservoir is just under 75% of the event related inputs. For the remainder of the summer, 90% of the bacteria in an event originates from rural sources(Figure 3).

The rural component represents 97% of the event related bacteria in Wildwood (Figure 3).

2.3.1.2 Urban and Industrial Impacts

For Fanshawe Reservoir, 50% of the bacteria originates from urban and industrial sources.

Improvements to industrial sources put into effect in late 1988 resulted in a 75% reduction in the effluents. Based on the CURB model the overall impact of industry next year is anticipated to be 10%. If effluent standards are to be similar to sewage treatment facilities, a further decrease at the beach would result. Therefore, future industrial contributions would represent approximately 1% of the overall impact at the beach. Refer to section 3.1.2 for expected water quality implications.

In Pittock Reservoir, the sewage lagoons have recently been upgraded. Expectations from these modifications are a reduction in the contribution to less than 1% of the overall beach impact. As a result, in 1989, over 90%of the bacteria in the reservoir is anticipated to be from rural inputs.

Refer to Section 3.1.3, which discusses the anticipated implications of the aforementioned abatement measures on reservoir water quality.

2.3.2 Total Phosphorus

From point of input to the drainage system to the reservoir, delivery of phosphorus was considered to be 100%. The model does not attempt to quantify uptake, sedimentation release or resuspension of phosphorus, but instead assumes there is no net sink of the nutrient within the drainage system. Phosphorus inputs were considered to occur year round as opposed to the seasonal die-off rates observed with bacteria.

Relative inputs of the identified sources were compared in a theoretical event situation. Erosion impacts were excluded from the graphic representation to highlight the other sources.

2.3.2.1 Rural Impacts

Erosion related phosphorus contributions were approximately equal to the annual inputs from all other identified sources (milkhouse, septic, livestock access, manure storage runoff, overspreading, winterspreading and urban). Of the rural inputs, erosion contributes between 45% (Pittock) and 50%+ (Wildwood) of the annual total phosphorus load.

In Fanshawe Reservoir, erosion notwithstanding, 50% of the remaining total annual load is from rural contributions. Milkhouse waste discharges (30%) and inadequate septic treatment (10%) were the two most significant sources (Figure 4).

With less urbanization in Pittock and Wildwood Reservoirs, rural phosphorus inputs other than erosion account for respectively 80% and 88% of annual loads. Milkhouse wastes and inadequate septic treatment again represent the most significant impacts next to erosion (Figure 4).

Under a hypothetical event situation with all sources other than erosion contributing simultaneously, effects of poor manure spreading practices, manure spills/discharges and uncontained manure runoff become more predominant (Figure 5). However, erosion is the single most significant input ranging from 65% of the total event load at Pittock to more than 80% for Fanshawe and Wildwood.

2.3.2.2 Urban and Industrial Inputs

In Fanshawe Reservoir, sewage discharge, urban non-point runoff and industrial inputs account for 25% of the total phosphorus load to the reservoir (Figure 4). The split is 50:50 when comparing urban and industry to all rural sources other than erosion.

However, recent industrial abatement measures, ‘on line’ in late 1988, are predicted to reduce phosphorus discharges by 70% (pers comm I.Nesjak MOE London). This represents an overall loading reduction to the reservoir of more than 10%. The predicted impacts of these measures on the reservoir are discussed in Section 3.1.2. Two of the three sewage treatment facilities (Stratford and St. Marys) have upgrades scheduled for completion by 1990. Anticipated effects are discussed in Section 3.1.2

Urban and industrial impacts are not as prominent in Pittock and Wildwood Reservoirs. Upgrades to the Tavistock lagoons, ‘on line’ in September 1988, are not expected to reduce overall phosphorus load. However, an altered schedule to continuous discharge should minimize the impact in event situations (Figure 5).

2.4 Field Evaluation

Just upstream of Fanshawe and Pittock Reservoirs are monthly water quality monitoring sites (Figure 1) sampled through the MOE Provincial Water Quality Monitoring Network (PWQMN). In association with these monitoring stations are Environment Canada Federal flow gauges. With the available summaries, daily loading estimates of phosphorus and bacteria were calculated for each sampled day for 1982 to 1987 (Appendix 2). These field loading estimates were compared to CURB model predictions.

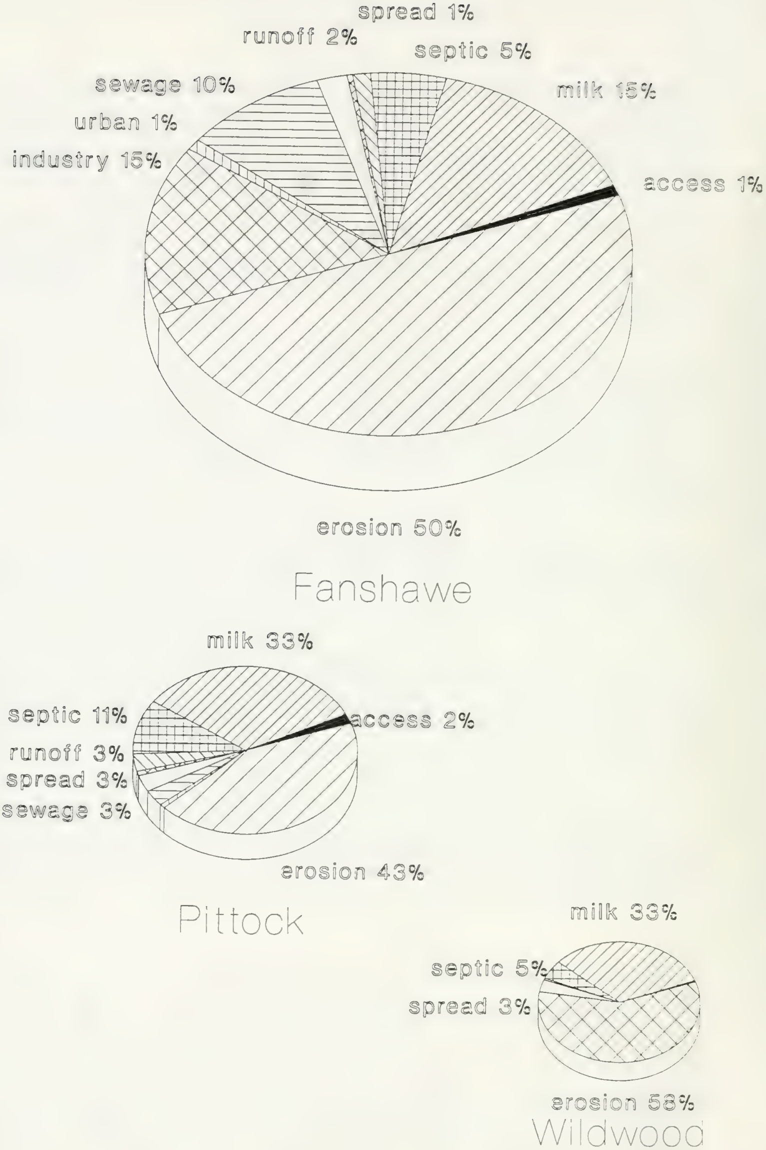
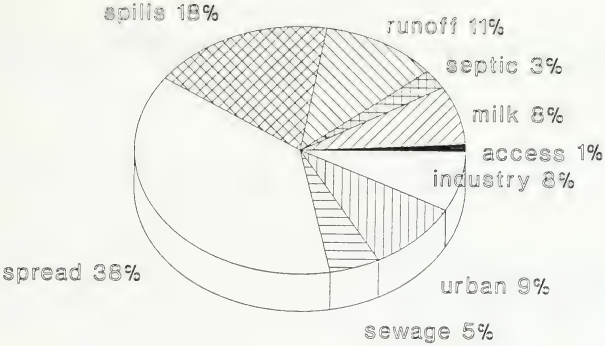
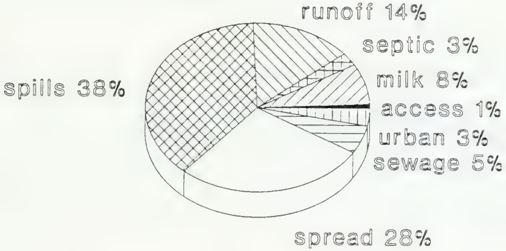


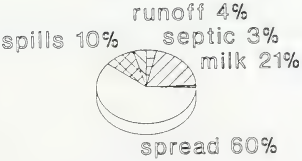
Figure 4: Relative Annual Contributions of Total Phosphorus to Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).



Fanshawe



Pittock



Wildwood

Figure 5: Relative Event Related Contributions of Total Phosphorus (erosion not included) to Fanshawe, Pittock and Wildwood Reservoirs (proportional pies).

Daily flow averages for the swimming season were compared to the downstream beach closure records for the years 1982 to 1988.

2.4.1 Fanshawe Reservoir

In low flows, fecal coliform inputs originate from livestock access, milkhouse washwater, unacceptable septic systems, sewage treatment facilities and industrial effluents.

Through the winter months, the CURB model predicts a 15% reduction in bacterial inputs accounting for absence of livestock at the access sites and discontinued effluent disinfection at the sewage treatment facilities. A review of Plover Mills data indicates typically lower bacteria concentrations in January and February as opposed to July and August under similar flow conditions (Appendix 2).

In flows of less than 5 cms (cubic metres per second) , field measured bacteria was an average 10% of the CURB model predictions (Figure 6), with ranges from 2% to 75%. As flows increased to between 5 and 10 cms, bacteria levels increased to within 45% of the CURB model low flow estimates. On several occasions the predictions were exceeded by up to a maximum 5 times (Figure 5). Above 10 cms, 63% of the event CURB model estimates were measured at Plover Mills with levels exceeding the model values by as much as 4 times (Figure 5).

Total phosphorus loadings to Fanshawe Reservoir are primarily from erosion impacts. The next most significant inputs are industry, milkhouse wastes, sewage discharge and unacceptable septic systems; all continuous contributors. In flows less than 5 cms, Plover Mills loadings are 25% of the model calculations. Ranges were from 10 to 40% (Figure 7). From 5 to 10 cms, two thirds of the predicted continuous inputs were measured at Plover Mills. Above 10 cms, 92% of the event predicted loads were measured. Some field values exceeded the model by as much as 5.5 times (Figure 7).

On average, the CURB model overestimates bacteria and phosphorus inputs but are within the same order of magnitude. Exceedence of the CURB predictions on occasion suggests sedimentation and resuspension does occur which further supports the representativeness of the model calculations. High field measured levels may also indicate above average runoff events, although due to the random nature of the PWQMN samples, it is unlikely peak concentrations were ever measured. In addition, the flows used are daily averages which would generally result in a further underestimate of field loadings.

Daily flow averages, at the Plover Mills federal station upstream of Fanshawe Reservoir, indicate a strong correlation between flow trends and beach closures. With the installation of an ultraviolet light treatment system for the beach area in 1988, beach closure data is not available for that year. Instead, samples taken outside the treated area were used to predict when a closure may have occurred.

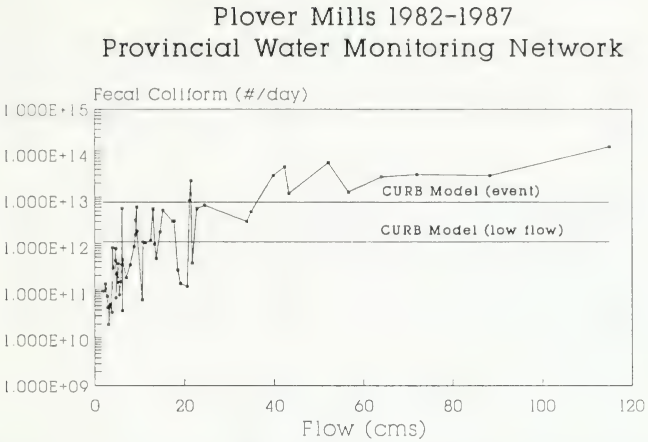


Figure 6: A Comparison of Plover Mills Fecal Coliform Data Versus CURB Model Predictions in Low Flow and Event Conditions

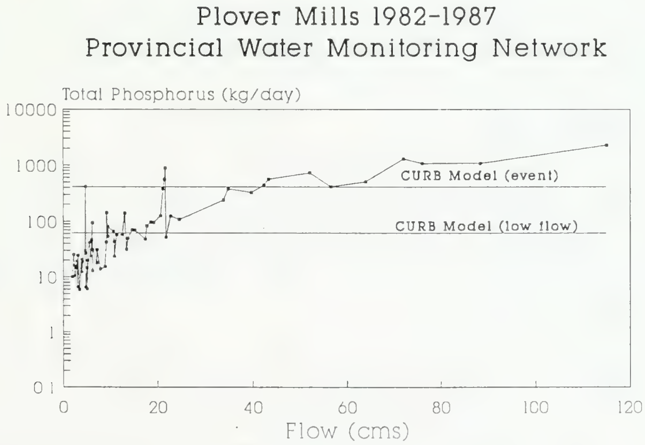


Figure 7: A Comparison of Plover Mills Total Phosphorus Data Versus CURB Model Predictions in Low Flow and Event Conditions.

Elevated bacteria levels were sufficient to close the beaches in 1983 (Figure 8) and theoretically in 1988. For both years, high flows were observed prior to the closure. Due to equipment problems, flow data is sketchy for 1988. However, an intense storm of 80 mm in 2 hours was recorded a few days prior to increased bacteria concentrations.

For the remainder of the years, flows did not exceed 20 cms in the summer months. Blue-green algae blooms appeared in each of these years (Figure 9). Timing of the bloom is usually twenty or thirty days after the last measurable flow increase (Figure 9). In 1987, an algae bloom was recorded in late June, the earliest ever. A comparison of average June flows for 1982 through 1986 with 1987 information, points out the low flow situation over most of June 1987. Again, the bloom appeared approximately twenty days after the last notable flow increase (Figure 10).

2.4.2 Pittock Reservoir

In summer low flow conditions, livestock access, milkhouse washwater and faulty septic systems are the most significant contributors of fecal coliforms. The CURB model predicts a 50% reduction in bacteria through the winter when cattle access sites are idle. Confirmation of this comes from a review of 1982 to 1987 data which indicates an order of magnitude difference in bacteria concentrations in January and February compared to similar flow conditions in July and August (Appendix 2).

Of the CURB predicted bacteria for summer conditions, 8% were measured at Innerkip in flows less than 1 cms. A maximum value was 230%above CURB predictions (Figure 11). In flows from 1 to 3 cms, 53% of the modelled bacteria were measured at the sample station. Low flow model estimates were exceeded by as much as 530%(Figure 11). Sixty three per cent of the event CURB model bacteria were measured when flows increased to more than 3 cms. The maximum was 4200% of predicted values(Figure 11).

Phosphorus contributions to Pittock Reservoir are primarily from erosion, milkhouse washwater and septic discharges. Nearly 20% of the predicted daily phosphorous inputs were measured at Innerkip with flows less than 1 cms. Ranges were within 40% of the CURB model. Between 1 and 3 cms, 100% of the modelled phosphorus was observed at Innerkip. Values were from 30 to 250% of the model. Over 3 cms, 72% of the total phosphorus event estimates were measured with loadings as high as 5 times the predicted value (Figure 12).

As with Fanshawe Reservoir, it appears the CURB model is reasonably representative of the relative impact of identified sources on beach water quality.

Daily Innerkip flow averages through the swimming season were compared to beach closures in Pittock Reservoir. In 1985 and 1986, the only years the reservoir was closed due to blue-green algae, there were major runoff events (greater than 10 cms) or a significant manure spill/discharge, separated by nearly twenty days of low flow conditions (Figure 13 and 14). Only one other year (1983) recorded summer daily

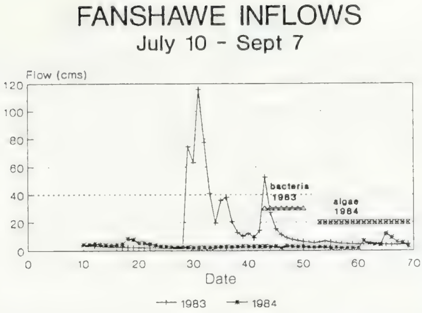


Figure 8: Plover Mills Flow Data Versus Fanshawe Beach Closures in 1983 and 1984.

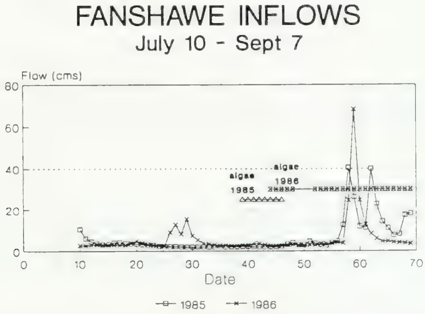


Figure 9: Plover Mills Flow Data Versus Fanshawe Beach Closures in 1985 and 1986.

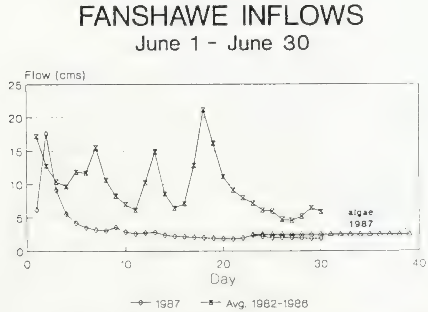


Figure 10: Plover Mills Flow Data Versus Fanshawe Beach Closures in 1987

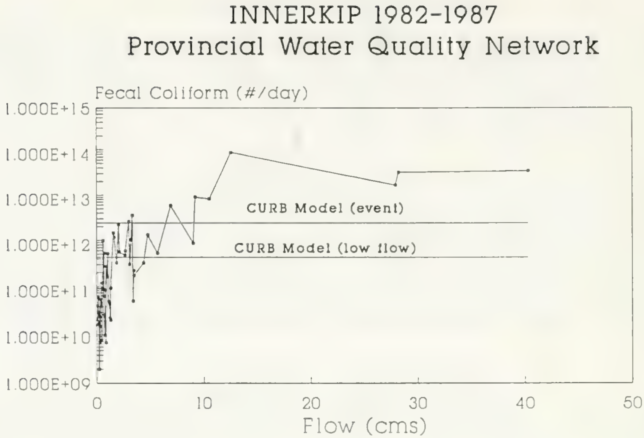


Figure 11: A Comparison of Innerkip Fecal Coliform Data Versus CURB Model Predictions in Low Flow and Event Conditions.

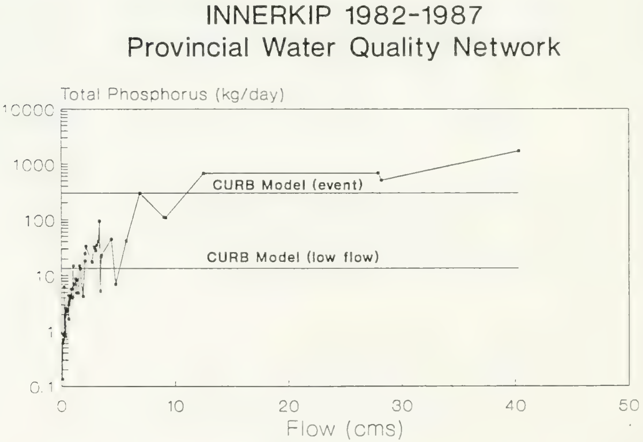


Figure 12: A Comparison of Innerkip Total Phosphorus Data Versus CURB Model Predictions in Low Flow and Event Conditions.

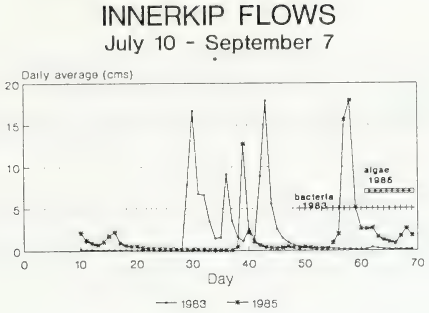


Figure 13: Innerkip Flow Data Versus Pittock Beach Closures in 1983 and 1985.

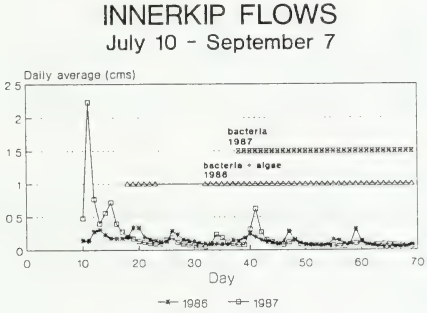


Figure 14: Innerkip Flow Data Versus Pittock Beach Closures in 1986 and 1987.

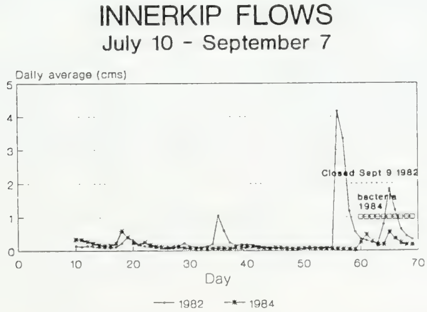


Figure 15: Innerkip Flow Data Versus Pittock Beach Closures in 1982 and 1984.

average flows greater than 5 cms. In late July and early August there were three major events. Elevated bacteria levels were recorded shortly after the third and final event. Low flow conditions persisted following the beach closure, however, no records were kept to determine whether or not a bloom occurred later in the 1983 swimming season (Figure 13).

In the remainder of the examined years, flows were usually below 0.5 cms. The earliest recorded beach closure was in early July 1986. This closing followed shortly after a manure spill upstream of Innerkip. Beaches reopened for just over a week then closed the rest of the summer for either blue-green algae or high bacteria counts (Figure 14).

For 1984, 1986, 1987 and 1988 elevated bacteria counts closed the beach in August, generally after a minor flow increase was recorded at Innerkip (Figures 14 and 15). Flows above 1 cms did not create beach closure conditions until the event tailed off towards base levels.

In 1982, the beach did not close until September. Based on more recent observations, it has been assumed beach sampling has become more rigorous and with todays standards, elevated counts would have been detected earlier in the 1982 season (Figure 15).

2.4.3 Wildwood Reservoir

Fecal coliforms are contributed to Wildwood Reservoir primarily from unacceptable septic systems and livestock access. Total phosphorus is predominantly from erosion, milkhouse washwater discharges and unacceptable septic systems.

Without a PWQMN station in close conjunction with a federal flow gauge, no attempt was made to graphically compare field monitored loading estimates with the model.

However, there was a review of the daily records at the Trout Creek federal flow station upstream of Wildwood(Figure 1) for July and August, 1982 through 1987. For every year, green algae blooms have been observed on the reservoir. Only in the past two years have beach closures resulted. However, for 1984 and 1988 the two years where elevated bacteria levels closed the beach, flows were well below average. In 1984, mean flows for July were .009 cms and .002 cms in August. In comparison, July and August average flows for the other years were respectively 0.27 cms and 0.16 cms (Water Survey of Canada). Although 1988 flows are as yet unavailable, summer drought conditions likely produced flows similar to or below 1984 levels.

3.0 CLEAN UP RURAL BEACHES PLAN

The three reservoir watersheds covered under this rural beaches program have experienced different closure histories.

In Fanshawe, blue-green algae blooms predominate. Elevated bacteria levels occur after significant flow increases.

Bacteria levels in Pittock gradually accumulate to pose a problem in early August. Minor flow increases are commonly required to initially increase fecal coliforms above the 100/100 ml safe swimming standard. Blue-green algae can be observed in most years, but blooms appear only after significant upstream inputs from summer storms or spills/discharges. Extended dry periods must follow to establish bloom conditions within the reservoir.

Meanwhile, in Wildwood Reservoir, elevated bacteria levels were recorded only after prolonged low flow conditions. Green algae can be seen in the reservoir, but has only recently been considered a potential swimming hazard.

These discrepancies can be explained based on an assessment of the reservoir physical properties (Table 3) and CURB model predictions.

From the model predictions, Fanshawe Reservoir watershed receives 4.5 times the phosphorus load of Pittock estimates. A comparison of flows at Innerkip and Plover Mills suggests a similar 4.5:1 discharge ratio once conversions have been included to account for flow increases between the stations and the reservoir. As a result, phosphorus concentrations should be similar for the two reservoirs. Appendix 2 indicates average phosphorus concentrations for Plover Mills(1.0 mg/l) and Innerkip(1.2 mg/l) were the same over the 1982 to 1987 period.

Therefore, the main difference between the two reservoirs, namely depth (Table 3), must have a significant impact on algae growth. Anoxic conditions (no oxygen) within the reservoir bottom water layer (hypolimnion) of Fanshawe Reservoir, established during extended droughts, result in a release of phosphorus from the reservoir sediments (pers comm H. Vandermeullen, MOE Toronto). The extra available nutrients help trigger an algae bloom. In Pittock, extensive anoxic zones would not form in the shallower depths of this reservoir. As a result, extra nutrients must originate from upstream events. If stagnant conditions persist to sufficiently elevate water temperature, an algae bloom will follow.

On the other hand, predicted bacterial inputs are of similar magnitude for the two study basins. Since flows are lower for Pittock Reservoir, bacteria is typically more concentrated (Appendix 2). Minor flow increases which precede Pittock beach closures would further elevate levels by enhancing delivery and resuspending bacteria previously accumulated within the drainage system sediments.

Table 3: Physical Properties of Fanshawe, Pittock and Wildwood Reservoirs

Characteristics	Pittock	Fanshawe	Wildwood
Surface Area(ha)	211	261	384
Mean Depth(m)	2.4	4.7	4.6
Orientation of Long Axis of Reservoir	northeast-southwest	north-south	east-west
Occurrence of Shoreline Erosion	at numerous locations	at numerous locations	rare
Flushing Time(days)	60	50	250
Drainage Area(km^2)	242	1450	141
Mode of Discharge Options	surface or bottom draw	surface or bottom draw	surface or bottom draw
Operational Mode	surface in winter, bottom rest of year	bottom draw or mixed	primarily bottom draw

adapted from: Gartner Lee and Associates, 1983

High flows tend to delay blue-green algae blooms in Fanshawe and Pittock Reservoirs. However, higher bacteria counts follow these increased flows. Since closures do not occur until flows begin to return to base level, it appears the improved bacteria delivery of continuous sources are the primary cause.

At Wildwood Reservoir, green algae can be observed in most years. Phosphorus inputs are considerably less than the other reservoirs, but sufficiently high to promote nuisance algae levels. In the two years where bacterial levels exceeded swimming standards, flows were well below average. Higher counts are likely due to stagnation of water in the beach area, which in turn accumlates fecal coliforms from decay of green algae and wildlife inputs. Sampling for E. coli a truer representative of fecal contamination would help better define the causal factors behind Wildwood beach closures.

3.1 Cost Effectiveness Analysis for Remedial Action

Average capital costs and operation expenses were estimated for remediation of each identified source. When several remedial options are available, the high and low capital cost projects were compared (Table 4, 5 and 6).

Dollar values for upgrading livestock operations were derived from several sources. Sizing requirements (fence length, treatment trench size and storage volumes) were calculated from summarized survey information (Table 1). Construction and operation costs were estimated on past UTRCA projects and discussions with R. Fleming (1988). When operation expenses were unknown, 5% of capital costs was assumed.

Cost of livestock access restriction does not include loss of pasture, additional feeding requirements nor benefits from reduced bank erosion or herd health impacts.

For upgrading manure storages, solid manure spreading was considered an existing cost and not calculated into the operation expense of a solid storage with runoff containment system. Conversion from solids to a completely liquid system eliminates the solid spreading expense which was factored into the analysis. Three dollars per ton was the cost attached to solid manure spreading for this calculation (Country Guide 1987).

Septic system prices were based on discussions with local health units and contractors. In some locations a traditional weeping bed is not practical due to soil conditions or physical space. Solutions for these situations could be more costly.

Urban and industrial figures represent estimates for proposed improvements or are based on actual costs incurred for similar projects elsewhere in the province (pers comm Operations and Abatement staff, MOE London).

There are many forms of soil conservation practices from a change in tillage direction to strip cropping to residue management through conservation tillage. However, no-till and mulch tillage side by side studies of the Tillage 2000 program provide the

Table 4: Cost Effectiveness Analysis for Abatement of Identified Sources within the Fanshawe Reservoir Watershed

Source Fanshawe	High/Low Cost Remedial Practice	Effectiveness (%)	Average Economic Life (years)	Capital Cost ($)	Amortized Cost ($/yr)	Maintenance Cost ($/yr)	Operation Cost ($/yr)	Total Annual Cost($)	Total Watershed Annual Cost($)	Annual Cost/Effectiveness	
										Fecal coliforms ($/1000000000 bacteria)	Total Phosphorus ($/kg)
Livestock Access	1)Fence one side +alt. water	100	5	3900	780	195		975	104325	3.00	217.00
	2)Fence both sides +restricted crossing	100	5 20	7800 7000	1560 350	390 350		2650	283550	7.00	591.00
Milkhouse Washwater	1)treatment trench	100	5	2400	480		100	580	118320	55.00	17.00
	2)concrete tank +land application	100	20	3300	165		255	420	85680	39.00	12.00
Septic Systems	1)tank +weeping bed	100	10	4000	400		30	430	224460	4.00	92.00
Manure Runoff	1)liquid lagoon+fence	100	20	4800	240		2100	2340	332280	92.00	572.00
	2)solid+concrete tank	100	20	22000	1100		600	1700	241400	67.00	415.00
	3)solid+lagoon	100	20	17300	865		750	1615	229330	63.00	395.00
Erosion	1)conservation tillage		10	10000	1000			1000	1567000	n/a	115.00
	2)targetting		10	10000	1000			1000	156700	n/a	11.00
Urban and Industrial	1)ultraviolet light		20	120000	6000	6000		12000	12000	18.00	n/a
	2)lagoons		20	100000	5000	5000	12000	22000	22000	1.00	4.00

Table 5: Cost Effectiveness Analysis for Abatement of Identified Sources within the Pittock Reservoir Watershed

Source Pittock	High/Low Cost Remedial Practice	Effectiveness (%)	Average Economic Life (years)	Capital Cost ($)	Amortized Cost ($/yr)	Maintenance Cost ($/yr)	Operation Cost ($/yr)	Total Annual Cost($)	Total Watershed Annual Cost ($)	Annual Cost/Effectiveness	
										Fecal coliforms ($/1000000000 bacteria)	Total Phosphorus ($/kg)
Livestock Access	1)Fence one side +alt. water	100	5	3900	780	195		975	36075	1.00	181.00
	2)Fence both sides +restricted crossing	100	5 20	7800 7000	1560 350	390 350		2650	98050	4.00	493.00
Milkhouse Washwater	1)treatment trench	100	5	2400	480		100	580	56260	27.00	17.00
	2)concrete tank +land application	100	20	3300	165		255	420	40740	20.00	12.00
Septic Systems	1)tank +weeping bed	100	10	4000	400		30	430	100620	2.00	93.00
Manure Runoff	1)liquid lagoon+fence	100	20	4800	240		2100	2340	145080	62.00	421.00
	2)solid+concrete tank	100	20	22000	1100		600	1700	105400	45.00	306.00
	3)solid+lagoon	100	20	17300	865		750	1615	100130	43.00	290.00
Erosion	1)conservation tillage		10	10000	1000			1000	362000	n/a	127.00
	2)targetting		10	10000	1000			1000	36200	n/a	13.00
Urban and Industrial	1)ultraviolet light		20	120000	6000	6000		12000	12000	1.00	n/a
	2)lagoons		20	2000000	100000	100000	12000	212000	212000	n/a	n/a

Table 6: Cost Effectiveness Analysis for Abatement of Identified Sources within the Wildwood Reservoir Watershed

Source Wildwood	High/Low Cost Remedial Practice	Effectiveness (%)	Average Economic Life (years)	Capital Cost ($)	Amortized Cost ($/yr)	Maintenance Cost ($/yr)	Operation Cost ($/yr)	Total Annual Cost($)	Total Watershed Annual Cost($)	Annual Cost/Effectiveness	
										Fecal coliforms ($/1000000000 bacteria)	Total Phosphorus ($/kg)
Livestock Access	1)Fence one side +alt. water	100	5	3000	600	150		750	7500	42.00	341.00
	2)Fence both sides +restricted crossing	100	5 20	6000 7000	1200 350	300 350		2200	22000	123.00	1000.00
Milkhouse Washwater	1)treatment trench	100	5	1800	360		100	460	23000	401.00	13.00
	2)concrete tank +land application	100	20	1600	80		255	335	16750	292.00	10.00
Septic Systems	1)tank +weeping bed	100	10	4000	400		30	430	25155	45.00	92.00
Manure Runoff	1)liquid lagoon+fence	100	20	4500	225		2100	2325	13950	122.00	698.00
	2)solid+concrete tank	100	20	6500	325		600	925	5550	49.00	278.00
	3)solid+lagoon	100	20	2200	110		750	860	5160	45.00	258.00
Erosion	1)conservation tillage		10	10000	1000			1000	191000	n/a	115.00
	3)targetting		10	10000	1000			1000	19100	n/a	11.00
Urban and Industrial	1)ultraviolet light		20	120000	6000	6000		12000	12000	n/a	n/a
	2)lagoons		20	2000000	100000	100000	12000	212000	212000	n/a	n/a

most complete and current economic analyses for Ontario conditions (OMAF 1987). In a cost comparison of conventional (fall moldboard plow) and no-till, an average $0.06/bushel savings in operational expenses was observed due to reduced 'pre-harvest activities' of no-till (OMAF 1987). Mulch tillage showed a $0.04/bushel savings. For this analysis, operational expenses were considered identical. The capital expense represents equipment acquisition.

An additional calculation was done to determine the cost effectiveness of targetting soil conservation efforts to only high priority areas. Coleman (1982) suggests 10% of the Avon River basin contributes 85% of the suspended solids load. Calculations for targetted soil conservation uses these figures with the assumption 10% of the land is represented by 10% of the farm operations.

Capital costs were amortized over the expected economic life of the project and/or equipment. A zero interest rate was used under the assumption interest equals inflation. The amortized cost was added to the annual operation cost to estimate the total annual cost of remediation of a typical input for each identified source. The annual cost was multiplied by the number of identified sources to provide an estimate of total annual expenses for each source by reservoir watershed. Total initial capital costs were also calculated.

Effectiveness was established strictly as an estimate of the reduction of fecal coliforms or total phosphorus at the beach area as predicted by the CURB model. Effectiveness of remediation was considered 100% for all sources but erosion, urban and industry.

Manure storage construction benefits also included the elimination of winter spreading effects for those particular farms. Since not all farms are dairy, transfer of milkhouse washwater to the storage was not included as a benefit in this particular section.

Anticipated improvements via conservation tillage were calculated using the Universal Soil Loss Equation (USLE). The C-factor of the USLE, which measures crop cover, varies with amount of residue left after planting. Based on C-factors for fall moldboard plow and no-till by crop type (Mohr 1988), estimates of erosion reduction were determined. Acreages of each crop type were determined by county proportions calculated from the Agricultural Statistics handbook (1986). Decreases in soil erosion were considered directly proportional to phosphorus loading reductions (Table 7). Since the majority of erosion occurs on a small percentage of land (Coleman 1982), a large proportion of the benefit could be realized by expending effort only in targetted areas.

Effectiveness assessment of urban and industrial effluent treatment was based on cost of improvements from the status as of the summer of 1988.

Most urban and industrial sources are undergoing or scheduled for further treatment improvements. Upgrades are generally targetted to parameters other than phospho-

Table 7: Predicted Phosphorus Loading Reductions From Adoption of Conservation Tillage

Reservoir	**Fanshawe**	**Pittock**	**Wildwood**
Drainage Area (ha)	130900	24200	14100
Estimated Cropland (ha)[1]	104720	19360	11280
Estimated Total[2] Phosphorus Load (kg)[2]	24085	4453	2594
Crops (ha)[1]			
Grain Corn	27755	8912	2990
Silage Corn	7208	1479	776
Soybeans	4828	1244	520
Fall Cereals	8639	1362	931
Spring Cereals	25391	2170	2735
Estimated Phosphorus Reduction (kg/yr)[3]			
Grain Corn	5376	1726	579
Silage Corn	1251	257	135
Soybeans	851	219	92
Fall Cereals	1452	229	156
Spring Cereals	4957	425	536
Total Phosphorus Reduction (kg/yr)	13905	2856	1489
Estimated Total Phosphorus Load (kg/yr)	10185	1597	1096

[1] Proportions determined from County Agricultural Statistics (1986)
[2] .23 kg/ha total phosphorus (SAREMP R-4 and CURB Plan Data)
[3] C-factor change between moldboard fall plow and no-till (Mohr 1988)

rus or bacteria. For these situations an attempt was made to estimate costs to comply with just phosphorus and bacteria reduction targets.

3.1.1 General Trends

For all three reservoirs, the most cost-effective measures for bacteria contamination reduction are livestock access restriction, septic system improvements and treatment of urban and industrial discharges.

Phosphorus loadings are most effectively controlled by targetted soil conservation measures. Milkhouse washwater treatment and upgraded septic systems are the next most effective treatment forms.

Manure storages are not as economical from an environmental standpoint as remediation of the other identified sources. However, there are fertilizer and organic benefits to manure which have not been included in the analysis. For most livestock farmers, this value is currently not considered. If soil and manure testing were adopted in conjunction with the storage construction, fertilizer savings would make this measure much more cost-effective.

3.1.2 Fanshawe Reservoir

Blue-green algae blooms have been the primary water quality concern for Fanshawe Reservoir. Low flow conditions for twenty to thirty days in the summer establishes nutrient, temperature and oxygen levels conducive to bloom growth. These conditions suggest low flow phosphorus loading is sufficient to support excessive aquatic vegetation populations. A release of phosphorus from the sediments in an anoxic hypolimnion (pers comm H. Vandermeullen, MOE Toronto) has been considered an extra 'boost' of nutrients.

By early fall 1988, industrial inputs at one source began extended treatment through upgraded facilities. Based on sample results collected after treatment went 'on line', annual total phosphorus loadings to Fanshawe Reservoir should be reduced by nearly 10%. Once target loads are met, a further 5% in reduction in total load could be realized.

The most cost-efficent phosphorus control method to reduce low flow concentrations is milkhouse washwater treatment (Table 6). With all milkhouse discharges adequately handled, pre-1988 loadings could be reduced 15%. Upgraded industrial treatment combined with proper management of milkhouse washwater would reduce the estimated annual phosphorus load by 30%. Low flow concentrations would be 45% of 1988 results.

Total capital costs for all milkhouse washwater treatment would range from $500,000 to $700,000 depending on the selected treatment method. Further research into alternate remedial methods should continue to improve economic life, operating costs and farmer acceptance.

Elevated bacteria levels are observed in Fanshawe after substantial rain events. Therefore, beach closures can be a result of a combination of all bacteria inputs. Improved delivery from source to beach is likely the significant factor.

With the industrial treatment and proper milkhouse washwater handling in place, as proposed for algae bloom control, annual bacterial inputs to the beach would be reduced 30%. Further industrial effluent treatment could lower beach levels by an additional 10%.

Other cost-effective bacterial reduction measures would be cattle access restriction, proper septic systems and extension of sewage effluent disinfection to include April discharges.

Capital costs for complete livestock access restriction would range from $100,000 to $1,700,000 and reduce bacteria inputs 10%. Completely new septic systems at all suspected problem sites would amount to around a $2,000,000 capital expenditure for a 25% reduction in bacteria inputs. These measures, along with the proposed phosphorus control, would mean a 75% reduction in total bacterial inputs. Low flow phosphorus concentrations would then be reduced a further 30%. In 1987 and 1988, phosphorus in the reservoir averaged 0.08 mg/l. Therefore, to reduce amounts below the 0.02 mg/l guidelines to avoid nuisance algae growth, a 75% reduction is needed. For this to occur, all milkhouse washwater discharges, livestock access and failed septic systems must be corrected.

Total initial capital costs for the required bacterial and phosphorus control would amount to between $2,600,000 and $4,500,000.

3.1.3 Pittock Reservoir

Elevated bacteria levels are the main cause of beach closures in Pittock Reservoir. Gradual accummulations of fecal coliforms are observed in the summer months. Closure occurs shortly after minor flow increases when bacteria which has settled to the sediments are resuspended and readily transported to the beach areas. High counts in the reservoir were not observed during excessive flows, an indication the majority of bacteria are from continuous discharges diluted by the runoff. Once flows drop, the dilution factor is reduced and coupled with improved delivery to the beach, concentrations rise.

The three most cost-effective solutions to elevated bacteria levels are chlorination or ultraviolet light treatment of the sewage lagoon discharge, livestock access restriction and upgraded septic systems.

In 1988, the Tavistock lagoons expansion was completed. Cleanup efforts were targetted to BOD and ammonia treatment. However, a side benefit to the new process will be reduced bacteria output. Therefore, additional disinfection may not be necessary. Follow-up sampling should be conducted to determine whether or not treatment goals have been accomplished. Based on predicted effluent amounts, bacteria at the beach should be reduced by about 10%.

Livestock access restriction at all identified sites would amount to a 30% reduction in annual bacteria inputs which affect the beach. Capital costs would range from $150,000 to $600,000 depending on the type of restriction technique adopted.

Upgrades to septic treatment would provide an even greater reduction than achieved through access restriction (45% of 1988 totals). Costs for installation of proper septic systems would be less than $1,000,000, about half the cost of the new lagoon expansion in Tavistock.

The expanded Tavistock lagoons, cattle access restriction and proper domestic waste treatment would provide a combined bacteria reduction of over 90% for a total extra capital outlay of $1,150,000 to $1,600,000.

Heavy blue-green algae blooms have occasionally been experienced in Pittock Reservoir. In most years, blue-green algae is present, but poses no serious threat. Water quality conditions in the reservoir would benefit from phosphorus loading reductions.

If the goals of the proposed bacteria management are achieved, phosphorus loading to the beach would be reduced by 20% (erosion inputs excluded). Proper management of milkhouse washwater would reduce low flow inputs by 55%. However, excessive blooms have been noted after significant runoff events. Contributions from erosion and manure runoff may still provide the nutrient levels necessary for bloom conditions.

3.1.4 Wildwood Reservoir

The primary beach closure problem in Wildwood is elevated bacteria levels. However, postings have occurred in only two years since 1982, both in summers with below average flow. Although bacteria counts are high in source waters to the reservoir (UTRCA files), it is believed the reservoir configuration and beach location combine to minimize impacts from upstream sources. Instead, beach closures have been attributed to stagnation and localized wildlife impacts. With green algae prevalent in the reservoir each summer, the most significant source of bacteria is likely a result of algal decay. Remedial action should be directed towards nutrient management.

The most cost-effective phosphorus reduction measures would be from erosion control, milkhouse washwater management and proper domestic waste treatment. In low flow conditions, milkhouse washwater discharges account for almost 80% of the phosphorus contributions to the reservoir. Significant improvements to background levels would be achieved through promotion of proper washwater handling. All sources could be remedied with a capital outlay of approximately $120,000 to $170,000.

Conservation tillage on the corn ground of Wildwood Reservoir would result in an annual phosphorus loading reduction similar to the anticipated benefits of the milkhouse waste treatment.

3.2 Implementation Strategy

Erosion and manure spills/discharges have long been recognized as threats to downstream water quality. Large-scale programs have been in place to address these problems. Although other rural sources have been previously identified, the magnitude of the impacts were not considered sufficient to seriously affect receiving water quality. However, the CURB plan in this report provides evidence significant changes in current rural land management practices will be necessary to improve downstream conditions. Milkhouse washwater discharges, livestock access and faulty septic systems should be the major abatement targets. Conservation authorities should be responsible for the proactive approach which is necessary to promote adoption of these remedial practices. In this manner, under direction of a multi-agency steering committee, effort can be targetted to corrections with the most environmental benefit for the local watershed. With the size of the UTRCA watershed, the density of livestock farming and number of identified potential pollution sites, two staff would be need to facilitate implementation, target efforts and monitor water quality changes.

The Ministry of the Environment published a document which outlines their water management guidelines (MOE 1978). Essentially, urban and industrial sources are subject to effluent guidelines developed on a site specific basis. Discharges are not to exceed federal or provincial regulations or guidelines, nor exceed the receiving waters assimilative capacity (MOE 1984). As of 1988, abatement facilities continue to be upgraded for the urban and industrial sources upstream of the three UTRCA reservoirs. With rural impacts only recently identified as significant problems, a time frame should also be permitted for adoption of remedial measures. A provincial policy on agricultural waste management is needed which covers environmental guidelines for all rural pollution sources.

Given the price structure for agricultural commodities, financial assistance should be available to these landowners to help fund capital intensive projects. Urban centres receive government assistance for similar projects to help reduce the financial burden on the individuals of the community

The alternative for rural source abatement is higher food prices to provide the landowner with more income. The problem then is to ensure all sources are corrected which could eventually result in non-voluntary participation. With good management a necessary ingredient in any rural source abatement measure, lack of farmer cooperation would be counter-productive.

Essentially, the CURB plan suggests all identified rural sources should eventually be corrected. What remains is the decision of each landowner to address specific problems on a priority basis. To act as a planning tool, a hypothetical farm was created which assesses typical bacteria and phosphorus inputs by source (Figures 16 and 17).

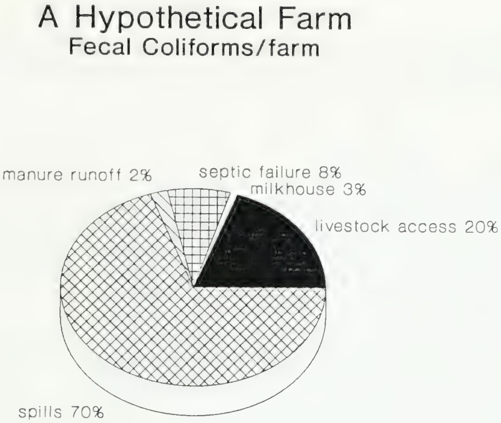


Figure 16: Average Fecal Coliform Inputs on a Hypothetical Farm with all Identified Rural Sources.

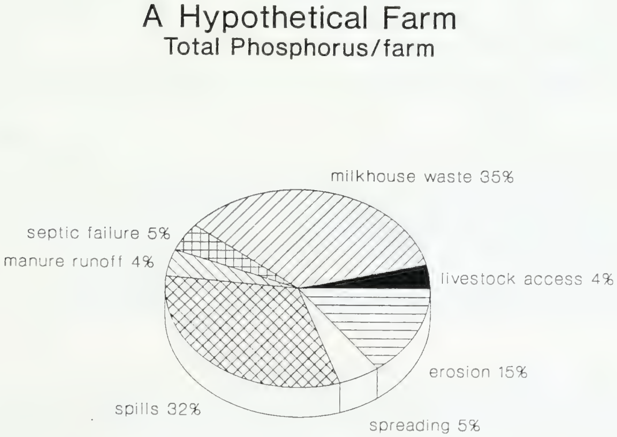


Figure 17: Average Total Phosphorus Inputs on a Hypothetical Farm with all Identified Rural Sources.

Naturally, the magnitude of a problem can vary from site to site. Also recognizing not all inputs occur on any one farm, a landowner can make management decisions based on both economic and environmental considerations.

3.2.1 Manure Spills/Discharges

With only a few occurrences in any one year, the collective impact of manure spills/ discharges at the beach area is relatively minimal. However, on an individual farm, a spill/discharge can be the most significant source of both bacteria and phosphorus for that year. Localized impacts, principally fish kills, are the most noticeable effect. As observed in the Pittock Reservoir area, above average spill/discharge volumes in low flow conditions can have serious downstream impacts.

In most situations, spills/discharges are unintentional although carelessness can be a big factor. Heightened awareness of precautions to take to prevent a spill/discharge would be beneficial. Each livestock operator should also have a contingency plan in the event of a spill/discharge which outlines the measures necessary to contain the effect. High profile information and educational programs by Conservation Authority and Ministry of Environment(MOE) staff would be necessary to promote these strategies.

Custom manure spreaders should be licensed by MOE and be accountable for tile drainage contamination from overspreading. They should be required by MOE to monitor tile outlets and implement a contingency plan in the event of problems to minimize any impacts. Animal units should be limited to the cropped land base. MOE and township councils need to review existing situations and develop strategies to prevent overspreading of manure.

Legal action should continue against intentional or unattended spills. Fisheries rehabilitation of the impacted stream should be incorporated into any fine for spill/discharge offenders. Since the inception of the 24 hour Spills Action Centre, delayed notification appears to still be the major deterrent to a successful investigation and prosecution. Periodic updates of the investigation, prosecutions or lack of evidence, either in the local paper or at least to the person who initiated the call would be a good MOE public relations gesture to enlighten the public on the overall process. Knowing something is actually being done might encourage more public participation.

For the rest of the discussion, spill/discharge effects have been eliminated to reflect the majority of farm situations.

3.2.2 Livestock Access

Livestock access to streams and drains, if present on a farm, can be the most significant source of bacteria. In order to achieve measurable improvements to receiving water quality, livestock must be removed from the watercourse. This approach is cost-effective from an environmental standpoint. The only benefit to the farmer is reduced bank erosion and potential herd health improvements from reduced exposure to pathogenic organisms.

Further studies initiated by the Ministry of Agriculture and Food(OMAF) should be conducted to attempt to quantify any relationship between access and herd health and/or production.

In many circumstances, the pasture is on the barn side of the watercourse. Restriction can be achieved with a fence along one streambank and alternate watering facilities. When pasture is located on the other side as well, the remedy is more complicated. Since at-grade crossings do not reduce bacterial inputs significantly (Ecologistics 1988), restricted crossings or alternate uses of the pasture area are the only solutions. Currently, there are no financial incentives to encourage a landowner to consider these alternatives. Yet, as much as ten times the capital outlay for a manure storage could be put towards livestock restriction to achieve the same bacteria and phosphorus reduction per dollar spent. These comparisons justify larger capital expenditures than presently put towards livestock crossing efforts. More work by OMAF should be done to develop reasonable cost-effective methods. Future OMAF/MOE joint grants should be better tailored to these remedial measures to permit more eligible items and alternatives. These grants should not fund livestock access projects other than restriction from the stream to maximize environmental benefit. Additional considerations should be given to compensation for pasture land taken out of production, similar to what is provided for highly erodible land within the Land Stewardship Program (LSP).

Beaches personnel employed in the implementation phase of the strategy should place their main emphasis on cattle restriction work. One to one landowner consultation should result in a satisfactory design which addresses specific problems encountered at each particular site.

The current 75% grant rate within the UTRCA watershed is viewed as adequate since some landowner interest has been generated. A more concentrated promotion effort would also increase the adoption rate.

3.2.3 Milkhouse Washwater

Milkhouse washwater discharges to open water is the second most significant source of phosphorus. It is the greatest factor influencing high phosphorus concentrations in low flow conditions. In addition, bacteria, BOD and chlorine can have a marked impact on local water quality. These all affect not only aquatic life and downstream conditions, but can possibly affect herd health or productivity of livestock watering nearby. There is not much doubt the elimination of these discharges is paramount for the improvement of water quality.

Presently, there are several options for the dairy farmer to treat wastewater. The milkhouse septic tank/treatment trench system has been redesigned to address problems encountered in the past. Trials have been installed at several farms in heavier soils. All have lasted without problems since installation as long as two years ago (Briggs, unpublished). Obviously more time will be necessary to adequately test the redesigned standards. These systems still require a high level of management to prevent milk spills from sealing the trench system. Only certified contractors should be permitted to install these treatment trench systems to ensure compliance with design standards.

Another alternative is storage for future land application. Most operators that select this option also contain runoff from the manure storage and feedlot areas. Once this is done, the capital outlay and annual spreading costs can be significant.

OMAF should initiate more research to waste treatment in an effort to develop more alternatives. Consideration could be given to grassed filter strips, artificially constructed wetlands, aeration of discharge, bacterial disinfection, reduced water use, etc. MOE should consider phosphorus limits for milkhouse wash chemicals.

With a few more years of study, designs will be available with proven track records. Once there are several reliable options to choose from, the industry could phase in treatment as a requirement for the sale of Grade A milk.

3.2.4 Unacceptable Septic Systems

Over the course of the rural beaches study, it became apparent unacceptable septic systems were more prevalent than previously believed. For the most part, the problems are bypasses of grey waste (sinks, showers, laundry, etc.) around the septic bed and into subsurface drainage tiles. In the cases of complete failure, systems are antiquated, unmaintained and/or in poor soil conditions.

Correction of illegal septic hookups will be difficult to monitor and enforce since the entire problem is underground. Walking of the drainage system will not identify all sources, particularily grey water effluents which do not always leave visible or odour evidence. There are a number of solutions which could correct the problem over the long term.

Currently, real estate transactions do not place emphasis on the size, location or maintenance of a septic field. If this information were included as a requirement of sale, new owners would be aware of conditions at the time of purchase. Costs of the survey should be borne by the landowner. A tax incentive program similar to the Canada Home Insulation Program (CHIP) with a requirement to have a registered Health Unit approval within the next five years would speed the process along. Septic tank and weeping bed design and installation done by a certified contractor would provide some assurance of construction standards. Sewage haulers should provide maintenance records for pumped tanks to the Health Unit and/or the landowner. Additional staff would be needed at each Health Unit to coordinate the program and inspect work. Some initial research is necessary to establish the number of households needing a registered approval to determine a schedule of compliance and staff requirements. MOE and CA staff could assist the Health Units in the development of a compliance program.

In the small communities which dot the watershed areas, lot sizes and/or soil types do not permit conventional technology. These situations must be resolved with aerobic systems (Class 6), holding tanks, lagoons with land application, construction of a wetland treatment system or development of new technology. In other areas, growth will require conversion to a communal treatment facility in the next decade. Each community should develop their long term waste treatment strategies through joint discussions with township or municipal councils, MOE and the county Health Units. Implementation should be completed within the next five years.

3.2.5 Manure Runoff

Although manure storage runoff does not pose an overall threat to reservoir water quality, ammonia, nitrates, total phosphorus, oxygen demand and solids are impactive on local conditions. Effluents exceed MOE standards whenever runoff occurs. For this purpose, improved manure storage facilities should continue to be promoted.

Joint OMAF/MOE initiated research is needed to determine the economics of manure storage and land application. Timing and application rates should also be reviewed to minimize surface, tile and groundwater contamination with an attempt to maximize crop benefits. Storage requirements should be reassessed to align with timing of spreading (ie. 200,300, 365, 365+ days storage). The Agricultural Code of Practice could then be revised to reflect environmental concerns. With all these factors in mind, a grant rate could then be developed to reflect the portion of cost not expected to be recouped by the farmer over a ten year period.

On a cost/effectiveness basis, the type of system selected for manure storage containment is not a big factor. Annual manure spreading costs for a lagoon (more rainwater to spread) counteract the low capital expense when compared to a tank. A cover on the tank increases capital expenses, but further reduces volume of liquids to be spread. More complete MOE guidelines and construction inspection should be in place to ensure standards are met and contamination of surface and groundwater is prevented.

Encouragement of soil and manure testing by OMAF and CA extension staff could help reduce fertilizer costs to offset the livestock operators annual expenses.

3.2.6 Erosion

Probably the most significant source of phosphorus for any one farm, control of erosion is also one of the most cost-effective phosphorus reduction approaches. Currently, many farms are at a stage of crop rotation, and tillage patterns which have erosion under manageable rates. As such, the effort expended in conservation tillage promotion could be more effectively delivered if targetted to the worst problems. This does not necessarily mean some farmers would be ineligible for assistance, but erosion rates should be used, in some form, as a priority ranking system. CA staff can place emphasis on a target approach to maximize the benefit to the reservoirs.

4.0 REFERENCES CITED

Coleman, D. E. 1982 Identification of Priority Management Areas in the Avon River Wateshed - Technical Report R-4. Stratford Avon River Environmental Management Project. Ministry of the Environment, London, Ontario.

Country Guide 1987 No Freebies from Manure Country Guide:January 1987 pg. 19.

Ecologistics Limited 1988 PLOP - A Planning Tool to Evaluate the Pollution Potential of Livestock Operations in Southern Ontario, Waterloo, Ontario.

Hayman, D. and C. Merkley 1986 Upper Thames River Rural Beaches Strategy Program - 1986 - Upper Thames River Conservation Authority.

Hayman, D. G. and W. E. Briggs 1987, Upper Thames River Rural Beaches Strategy Program - Summary of 1987 Activities - Upper Thames River Conservation Authority, London, Ontario.

Kress, M. and G. F. Gifford 1984 Fecal Coliform Release from Cattle Fecal Deposits. Water Resources Bulletin Vol 20 NG.1.

Mohr, P. 1988 Assessment of a Method of Monitoring Phosphorus Reduction from Cropland. Submitted to the Environmental Monitoring and Modelling Committee.

Ontario Ministry of Agriculture and Food 1986 Agricultural Statistics for Ontario Publication 20 Ontario Ministry of Agriculture and Food, Toronto.

Ontario Ministry of Agriculture and Food 1987 Tillage 2000 Soil Conservation 1987 Progress Report, Ontario Ministry of Agriculture and Food, Guelph, Ontario

Ontario Ministry of the Environment 1982-1987 Provincial Water Quality Monitoring Network, Unpublished data.

Ontario Ministry of the Environment 1984 "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment". Toronto, Ontario.

Ontario Ministry of Municipal Affairs 1988 Municipal Directory 1988. Ontario Government Bookstore, Toronto, Ontario.

Water Survey of Canada 1982-1987 Surface Water Data - Ontario Inland Waters Directorate, Environment Canada.

Robinson, J. B. and D. W. Draper 1978 A Model for Estimating Inputs to the Great Lakes from Livestock Enterprises in the Great Lakes Basin. Report for IJC PLUARG Task Group C, Activity 1, 29 pp.

Appendix 1: CURB Model

CONTINUOUS

Livestock access

	# of farms x	#/defecation (kg/)	prob of defc^n x	# of waterings x	days of access x	% of day[2] x	# of animal units
fecal coliforms	Survey	8.90E+08[1]	0.18	2.50	180.00	Survey	Survey
total phosphorus	Survey	1.20E-03	0.18	2.50	180.00	Survey	Survey

Milkhouse

	# of farms x	volume /day x	#/litre x	discharge days x	growth
fecal coliforms	Survey	Survey	2000	365	500
total phosphorus	Survey	Survey	35		

Unacceptable Septic systems

	# of homes x	l/person x	people/house x	#/l (kg/)[5] x	% faulty x	discharge days
fecal coliforms	Survey	137.00[3]	3.10[4]	1.00E+07	0.30	365.00
total phosphorus	Survey	137.00	3.10	3.00E-05	0.30	365.00

PULSE

Manure/Feedlot[6]	# of problems x	#/ha-mm (kg/)[5] x	storage area(ha) x	rainfall(ha-mm)[7] x	delivery
fecal coliforms	Survey	5.00E+09	Survey	600	0.70
total phosphorus	Survey	0.25	Survey	600	0.70

Manure Spills/Discharges

	# of problems x	volume/spill (l) x	#/litre(kg/)
fecal coliforms	MOE Estimate	MOE Estimate	1.80E+07[8]
total phosphorus	MOE Estimate	MOE Estimate	5.00E-04

Manure Spread Total Produced
Vol. Produced*5.0e+11(#/m^3)[9]
Vol. Produced*0.662(kg/m^3)

winter	total x	% vol. produce x	operators spread[10] x	amount spread[11] x	delivery to stream[12] x	storage survive[11]	field surv
fecal coliforms	above cal^n	0.25	0.47	0.75	0.016	1.00E-02	3.40E-02
total phosphorus	above cal^n	0.25	0.47	0.75	0.016		

Manure Spread

summer (too many AU/acre)	total	(vol. left -	minus access)[11] x	op. overspread x	amount overspd.[11] x	delivery to stream	field +stor. surviv
fecal coliforms	4.49E+17	4.09E+17	see	0.05	0.25	0.016	3.40E-04
total phosphorus	5.95E+05	5.42E+05	above	0.05	0.25	0.016	

Sewage - 1988 conditions

fecal coliforms	MOE Estimates
total phosphorus	MOE Estimates

Urban Non-Point Source

	area(ha) x	rain (m^3/ha) x	#/m^3(kg/)
fecal coliforms	County Health Unit	2845	1.10E+07
total phosphorus	County Health Unit	2845	9.00E-05

---

1 - pers comm, M. Young, MOE, 1988
2 - not always 100% of day; location factor removed with information unavailable
3 - pers comm, M. Bragg, Oxford County Board of Health, 1988
4 - Municipal Directory, 1988
5 - ABCA and/or UTRCA information
6 - Feedlot information generally included in manure storage area therefore no feedlot calculations
7 - pers comm, B. Fuller, MVCA 1988 (not all rainfall generates runoff)
8 - pers comm, G. Palmateer and W. Cook, MOE London, 1988
9 - OMAF Agricultural Statistics and Survey Information
10 - Coleman, 1982
11 - UTRCA Steering Committee and literature review (Thelin and Gifford 1983)
12 - Robinson and Draper, 1978; UTRCA information

Appendix 2a: Innerkip(Pittock)

Date mm/dd/yy	FC #/100ml	TP mg/l	flow cms	loadFC #/day	loadTP kg/day
07/20/83	480	0.19	0.056	2.3E+10	0.92
08/22/84	332	0.025	0.062	1.7E+10	0.13
08/18/87	600	0.078	0.089	4.6E+10	0.60
07/22/87	330	0.07	0.101	2.8E+10	0.61
06/17/87	650	0.063	0.126	7.0E+10	0.69
07/22/82	300	0.061	0.133	3.4E+10	0.70
05/23/85	108	0.047	0.208	1.9E+10	0.84
02/17/82	10	0.314	0.23	1.9E+09	6.24
06/22/83	68	0.036	0.28	1.6E+10	0.87
05/20/87	236	0.029	0.314	6.4E+10	0.79
02/20/85	28	0.096	0.315	7.6E+09	2.61
10/17/84	90	0.026	0.35	2.7E+10	0.79
09/19/84	390	0.06	0.432	1.4E+11	2.24
02/12/87	20	0.059	0.48	8.2E+09	2.45
07/18/84	2300	0.085	0.599	1.1E+12	4.40
10/20/82	200	0.031	0.618	1.0E+11	1.66
10/18/83		0.054	0.645		3.01
06/23/82	130	0.065	0.673	7.5E+10	3.78
08/17/83	1080	0.057	0.683	6.3E+11	3.36
01/17/84	48	0.074	0.69	2.8E+10	4.41
05/18/83	16	0.061	0.769	1.0E+10	4.05
11/21/84	140	0.08	0.84	1.0E+11	5.81
01/21/87	10	0.055	0.86	7.4E+09	4.09
09/22/82	440	0.051	0.883	3.3E+11	3.89
05/24/84	220	0.168	1.02	1.9E+11	14.81
05/20/82	700	0.046	1.03	6.2E+11	4.09
04/21/87	60	0.076	1.1	5.7E+10	7.22
12/19/84	50	0.067	1.2	5.1E+10	6.95
04/16/85	24	0.083	1.23	2.5E+10	8.82
12/21/83	20	0.073	1.3	2.2E+10	8.20
03/22/83	100	0.043	1.3	1.1E+11	4.83
09/21/83		0.039	1.45		4.89
06/20/84	1300	0.112	1.56	1.7E+12	15.10
04/18/84	1000	0.094	1.63	1.4E+12	13.24
08/20/86	244	0.026	1.87	3.9E+11	4.20
11/23/83		0.104	2.04		18.33
06/19/85	1500	0.14	2.05	2.6E+12	24.80
02/22/83	370	0.182	2.12	6.7E+11	33.34
11/16/82	250	0.076	2.66	5.7E+11	17.47
07/22/86	310	0.076	2.67	7.1E+11	17.53
09/17/86		0.132	2.83		32.28
06/18/86	1210	0.106	3	3.1E+12	27.48
04/19/83	136	0.131	3.09	3.6E+11	34.97
03/17/87	444	0.146	3.22	1.2E+12	40.62
08/26/82	1500	0.326	3.33	4.3E+12	93.79
11/18/86	20	0.018	3.4	5.8E+10	5.29
02/18/86	90	0.072	3.47	2.6E+11	21.59
04/22/82	70	0.076	3.48	2.1E+11	22.85

Appendix 2a:(cont.) Innerkip(Pittock)

03/19/85	104	0.118	4.38	3.9E+11	44.65
10/22/86	388	0.017	4.76	1.5E+12	6.99
12/16/86	130	0.083	5.69	6.3E+11	40.80
03/21/84	1190	0.5	6.9	7.0E+12	298.08
02/21/84	136	0.143	9	1.0E+12	111.20
04/22/86	1380	0.138	9.17	1.0E+13	109.34
05/22/86	1100		10.5	9.9E+12	0.00
02/03/83	9800	0.63	12.5	1.0E+14	680.40
03/18/86	840	0.284	27.9	2.0E+13	684.60
01/21/86	1600	0.21	28.2	3.8E+13	511.66
03/18/82	1200	0.49	40.3	4.1E+13	1706.14
avg.	**230**	**0.12**		——	——

Appendix 2b: Plover Mills(Fanshawe)

Date	FC	TP	flow	loadFC	loadTP
mm/dd/yy	#/100ml	mg/l	cms	#/day	kg/day
08/17/87	70	0.062	1.85	1.1E+11	9.91
06/16/87	60	0.132	2.19	1.1E+11	24.98
08/21/84	80	0.079	2.35	1.6E+11	16.04
07/19/83	60	0.05	2.41	1.2E+11	10.41
08/19/86	36	0.061	2.79	8.6E+10	14.70
07/23/86	20	0.08	2.83	4.8E+10	19.56
05/19/87	20	0.025	3.06	5.2E+10	6.61
02/16/82	8	0.091	3.1	2.1E+10	24.37
05/18/82	20	0.02	3.41	5.8E+10	5.89
01/19/82	12	0.063	3.8	3.9E+10	20.68
10/16/84	290	0.036	3.91	9.7E+11	12.16
07/16/85	100	0.052	4.11	3.5E+11	18.47
07/17/84	130	0.074	4.59	5.1E+11	29.35
08/20/85	230	1.02	4.7	9.3E+11	414.20
07/21/82	64	0.065	4.73	2.6E+11	26.56
05/22/85	20	0.016	4.73	8.1E+10	6.54
02/11/87	64	0.034	5	2.7E+11	14.69
10/19/82	40	0.014	5.02	1.7E+11	6.07
09/21/82	100	0.044	5.18	4.4E+11	19.69
01/16/84	20	0.09	5.5	9.5E+10	42.77
02/17/86	36	0.046	5.8	1.8E+11	23.05
02/21/85	80	0.09	6	4.1E+11	46.66
07/21/87	1300	0.178	6.12	6.8E+12	94.12
06/20/83	8	0.024	6.17	4.2E+10	12.79
02/01/83	100	0.058	6.2	5.3E+11	31.07
09/17/85	36	0.029	7.08	2.2E+11	17.74
09/20/83		0.05	7.1	0	30.67
11/17/86	60	0.02	7.88	4.0E+11	13.62
01/20/87	136	0.02	8.8	1.0E+12	15.21
08/16/83	236	0.054	9.11	1.8E+12	42.50
08/25/82	484	0.18	9.13	3.8E+12	141.99
06/17/86	910	0.066	9.41	7.3E+12	53.66
09/18/84	272	0.098	9.45	2.2E+12	80.02
04/20/87	8	0.072	10.6	7.3E+10	65.94
10/17/83		0.046	10.8	0	42.92
05/22/84	140	0.025	10.8	1.3E+12	23.33
03/21/83	128	0.059	11.3	1.2E+12	57.60
12/16/85	130	0.053	12.5	1.4E+12	57.24
06/21/82	600	0.125	13	6.7E+12	140.40
05/16/83	100	0.027	13.4	1.1E+12	31.26
12/15/86	48	0.042	13.7	5.6E+11	49.71
11/19/84	170	0.056	14.6	2.1E+12	70.64
12/20/83	480	0.053	15.2	6.3E+12	69.60
Avg.	**78**	**0.10**		—	—